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Comparison of the Polychaetous Annelids Populations on Suspended Test Panels in Los Angeles Harbor in 1950-1951 with the Populations in 2013-2014

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Abstract.—A 14-month study was conducted of the polychaetous annelids present on attached wooden blocks at nine stations in Los Angeles Harbor in 2013-2014. The results were compared to a similar study conducted at the same stations in 1950-1951. The primary objective in both studies was to determine the location and occurrence of marine borers in the harbor. Since fouling organisms, including polychaetes, attached to the wooden blocks, it also provided an opportunity to study the polychaetes that settled on the blocks. The number of polychaete species in these two studies increased from 22 to 71. The serpulid *Hydroides elegans* was a dominate species in both studies but the pollution indicator *Capitella capitata*, common in the earlier study, was rare in the recent study. There was a seasonal occurrence in both the number of species and specimens with highs in the warmer months and lows from December through March in both studies. Many environmental changes have occurred in the Los Angeles Harbor complex over the past 63 years. New harbor piers constructed that extend into the Outer Harbor, channels have been dredged deeper and pollution abatement programs initiated. The water quality has been improved especially in the Inner Harbor as a result of these changes where the dissolved oxygen in the water was low or absent in 1950-1951 but higher (over 6.0 mg/L) in 2013-2014. This study is unusual since long-term, seasonal comparisons of marine invertebrate populations are uncommon.

Los Angeles Harbor (the Harbor) is a world port and was the site of the first study of marine pollution using benthic organisms as a measure of water quality in the United States (Anon 1952). Polychaetes were the principle benthic animals and were the subject of seasonal comparisons (Reish 1955). Published and unpublished reports of environmental studies have continued since the initial study[1,2] (Soule and Oguri 1976). The purpose of this study is to determine if there have been changes in the settlement of larval polychaetous annelids on suspended wooden test panels in Los Angeles Harbor since 1950-1951 (Reish 1971b). The earlier and present studies were done as a companion to the study of the seasonal occurrence of marine wood boring organisms (Menzies et al. 1963; Reish 1971; Reish et al. 2015). Polychaetes have served as convenient indicators of environmental water

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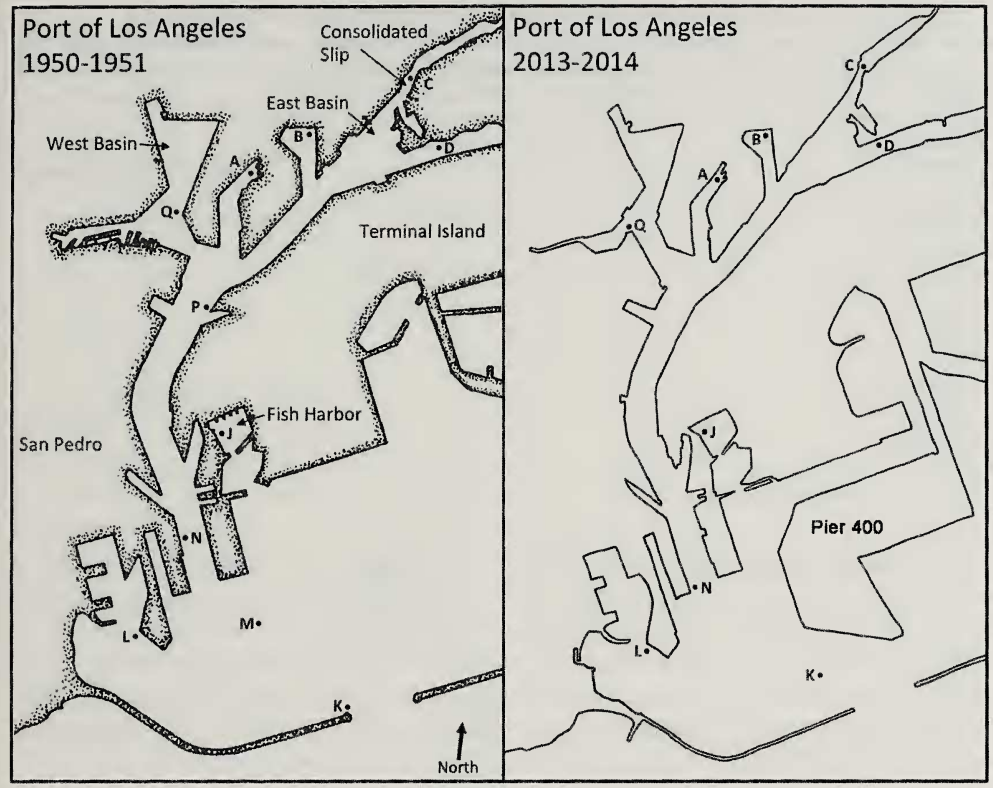

Fig. 1. Map of the Port of Los Angeles Harbor showing the station locations in the survey conducted in 1950-1951 (a). Map of the Port of Los Angeles Harbor showing the station locations for the survey of 2013-2014 (b).

conditions since the 1950s (Reish 1955). Since the earlier study was done before the initiation of pollution abatement (Reish 1971a), repeating the study will provide evidence of the effect of Harbor environmental improvement. The history of the wood-borering animals and fouling organisms in the Harbor has been detailed in Menzies et al. 1963; Reish et al. 2015. The changes in the presence of wood-borers occurred especially in the Inner Harbor and showed that pollution abatement resulted in increases of these animals where previously there were few or none (Reish et al. 2015). No study of wood-borering populations have been done between the two studies, but the wood-boring teredinids and isopod *Limnoria tripunctata* have been collected from the harbor for laboratory experiments (Eckelbarger and Reish 1973; Anderson and Reish 1967; Reish and Hetherington 1969). However, many studies have been conducted on polychaetes as fouling organisms on suspended test panels (Reish 1961; Soule and Oguri 1976), on floating docks (Crippen and Reish 1971), rock riprap[1], and soft-bottom benthos (Reish et al. 1980). Dredging of the Port of Los Angeles and Port of Long Beach complexes in the past 50 years has increased the importance of the available habitats as a nursery for nearshore fishes (Cross and Allen 1993).

Materials and Methods

The stations selected coincided in so far as possible as those selected in 1950-1951 (Reish et al. 2015 Fig. 1). The study began on 18 August 2013 and terminated on 1 October 2014.

Table 1. Dates of collection of test panels and exposure period.

Date	Short Term Period Number of Days	Long Term Period Number of Days
August 18, 2013	Initiation of Study	
September 23	28	
October 21	28	
November 18	28	
December 16	30	114
January 20, 2014	35	
March 17	56	119
May 12	28	
June 9	28	
July 14	35	
August 7	24	114
September 3	27	
October 1	28	55

Station locations described in Reish et al. (2015), noted below, and indicated in Fig. 1. One wood block (3.5 × 3.5 × 15 cm) attached to a rope, connected to a permanent harbor floating wooden structure and suspended three feet below the water surface. Wood blocks exposed, usually for 28 days, at which time removed and replaced with new blocks. A second block was attached at selected stations and exposed for a three-month period which was specifically used for the identification of teredinid wood-borers. Dominant organisms noted. Organisms scraped from the blocks, preserved in formalin and transported to the laboratory. Identification of polychaetes was by Charles Phillips and Thomas Gerlinger using procedures and taxonomic standards of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT). Species nomenclature was based upon the SCAMIT Taxonomic Species Listing Macro and Megafauna Invertebrates for the Southern California Bight (Edition 11, 2016) and WoRMS (2017). The specific dates and length of exposure of wood blocks for both the short-and-long term periods are in Table 1. Fouling organisms scraped from the long-term exposed period for wooden blocks were nalyzed separately. Measurements made at each station each time for water temperature and dissolved oxygen concentration with CRM's YSI 556 multi-parameter meter at a depth of three feet below the water surface from the research vessel. Data were summarized by station as range and means in Reish et al. (2015).

Results

A total of 71 species/morphotypes was identified in 2013-2014 or 41 if those worms identified to family or genus are considered as immature specimens with those identified to species in comparison to those found in 1950-1951 (Table 2). There was a seasonal difference in species richness (number of species), with higher richness present from June through October 2014 and lower richness during the winter months (Table 3). The two serpulid species *Hydroides elegans* and *Neodexiospira pseudocorrugata* were found at all stations except Station K in the outer harbor but were often absent during the winter months. The nereid *Platynereis bicanaliculata* settled on the wood blocks in the Outer Harbor stations, especially Station K, from December 2013 through July 2014. *Exogone lourei, Epigamia/Myrianida* complex, and additional species of syllids, were found sporadically and at any time throughout the harbor area. The same species were also dominant on the

Table 2. Comparison of the polychaetes collected from the short term exposed blocks in 1950-1951 with those collected in 2013-2014.

Family/Species	1950-1951	2013-2014
Capitellidae		
Capitella capitata Cmplx	X	X
Chaetopteridae		
Chaetopterus variopedatus Cmplx		X
Chrysopetalidae		
Palaenotus bellis	X	
Cirratulidae		
Cirratulus sp.		X
Cirratulus spectabilis		X
Cirriformia sp.		X
Kirkegaardia siblina		X
Protocirrinereis sp.		X
Ctenodrilidae		
Ctenodrilus serratus	X	
Dorveillidae		
Dorvilleas (S.) annulata	X*	X
Ophryotrocha sp.		X
Hesionidae		
Oxydromus pugettensis	X**	
Maldanidae		
Euclymeninae	X	
Nereididae		
Neanthes acuminata Cmplx		X
Neanthes sp.		X
Nereididae		X
Platynereis bicanaliculata	X	X
Opheliidae		
Armandia brevis	X	X
Ophelina sp.		X
Polyophthalmus pictus		X
Phyllodocidae		
Phyllodoce (*Anaitides*) sp.		X
Eteone sp.	X	
Eulalia quadrioculata		X
Eumida sanguinea	X	
Phyllodoce sp.		
Phyllodocidae		X
Phyllodoce longipes		X
Phyllodoce medipapillata		X
Polynoidae		
Halosydna johnsoni		X
Halosydna brevisetosa	X	X
Harmothoe imbricata Cmplx		X
Lepidonotus sp.		X
Lepidontinae		X
Polynoinae		X
Sabellidae		
Bispira sp.		X
Euchone limnicola		X
Fabricidae		X
Paradialychone ecaudata		X
Parasabella sp.		X
Parasabella fullo		X
Pseudopotamilla sp.		X
Sabellinae		X

Table 2. Continued.

Family/Species	1950-1951	2013-2014
Serpulidae		
Hydroides sp.		X
Hydroides elegans	X***	X
Hydroides gracilis		X
Neodexiospira eximia		X
Neodexiospira pseudocorrugata		X
Protolaeospira eximia		X
Serpulidae		X
Spirorbinae		X
Spionidae		
Boccardia proboscidea	X	
Carazziella sp.	X	
Dipolydora socialis		X
Polydora sp.		X
Polydora cornuta		X
Polydora limicola	X	X
Prionospio sp.		X
Prionospio heterobranchia		X
Prionospio pygmaeus		X
Pseudopolydora paucibranchiata		X
Pseudopolydora sp.		X
Spionidae		X
Syllidae		
Brania brevipharyngea		X
Epigamia/Myrianida Cmplx		X
Eusyllis sp.		X
Eusyllis transecta	X	
Eusyllinae		X
Exogone dwisula		
Exogone lourei	X	X
Exogone sp.		X
Megasyllis nipponica		X
Odontosyllis phosphorea	X	
Proceraea prismatica	X	
Salvatoria californiensis		X
Sphaerosyllis californiensis		X
Syllis gracilis Cmplx	X	X
Typosyllis sp.		X
Typosyllis alternata		X
Typosyllis heterochaeta	X	
Typosyllis fasciata	X	
Typosyllis variegata		X
Terebellidae		
Eupolymnia heterobranchia		X
Pista brevibranchiata		X
Polycirrus sp.		X
Nicolea sp.	X	
Terebellinae		X
Total number of species/morphotypes	22	71_

*Reported as *Stauronereis rudolphi*.
**Reported as *Ophiodromus pugettensis*.
***Reported as *Hydroides pacifica*.

Table 3. Seasonal occurrence of the number of species by station collected on the short-term exposure periods in 2013-2014 collection dates.

	9/13	10/13	11/13	12/13	1/14	3/14	4/14	5/14	6/14	7/14	8/14	9/14	10/14
A	19	12	2	0	1	1	3	1	23	39	53	33	49
B	15	17	15	9	10	6	10	1	41	35	29	28	19
C	11	21	13	4	2	7	7	1	13	13	12	10	13
D	20	31	6	2	0	5	5	1	55	26	15	7	17
J	28	31	12	7	4	8	47	2	138	37	14	30	46
K	0	5	2	5	8	2	5	0	9	8	0	0	4
L	0	7	1	8	5	10	17	2	21	18	7	5	7
N	5	4	6	1	2	8	9	1	3	27	3	4	3
Q	0	7	3	1	1	0	1	1	1	12	3	4	11

long-term exposed wood blocks with the addition of the sabellid *Paradialychone ecaudata.* Data are summarized by station with the dominant polychaetes species indicated.

Station A in Inner Harbor Slip 1: 240 specimens, 19 species (Table 2). Peaks in numbers occurred in Fall 2013 and Spring-to-Fall in 2014. The serpulids *Hydroides* and *Neodexiospira* species dominated with occasional occurrences of different species of syllids. Station B in Inner Harbor Basin 5: 243 specimens, 22 species. *Hydroides* and *Neodexiospira* dominated during the wormer months. Station C in Consolidated Slip: 122 specimens, 25 species. The serpulids *Hydroides* and *Neodexiospira* and the syllid *Exogone lourei* were the principle species. *Exogone* dominated the December-January period with the two serpulids dominating the rest of the year. Long-term test panels were exposed for three time periods extending from January through October 2014. There was a diversity of species of which 31 species and 223 specimens were present with the serpulid *Neodexiospira pseudocorrugata,* the syllids *Exogone lourei* and *Epigamia/Myrianida* complex dominating the abundances. Station D in Cerritos Channel: 196 specimens, 18 species. No species were dominant. However, many *Hydroides elegans* were present in the November and June collection periods but absent from the other periods. The syllids *Exogone lourei* and the species complex of *Epigamia/Myrianida* were present occasionally in small numbers. A total of 32 species and 320 individuals were taken from the four test panels exposed for the longer period of time. Serpulid species were the most common followed by different syllid species. Members of nereids, polynoids, sabellids, and spionids were also present. Greater numbers were present in the fall and spring months. Station J in Fish Harbor: 142 specimens, 29 species. *Hydroides elegans* accounted for 87% of the polychaetes collected. Peak abundances of this species were in fall 2013 and June through October 2014. Station K in the Outer Harbor at a channel marker: 50 specimens, 12 species. The nereid *Platynereis bicanaliculata* was the most common species taken which was present in all collection periods except the fall 2013. *Platynereis* accounted for 50% of the specimens taken from the short-term test panels and 26% from those exposed for the longer periods. A total of 136 specimens in 19 species was collected from the long-term exposed panels. Station L at the entrance to West Basin near the Fire Station: 114 specimens, 23 species. *Platynereis bicanaliculata* and the syllid *Exogone lourei* accounted for 50% of the specimens present on the short-term test panels. A total of 34 species and 294 specimens were taken from the four long-term test panels which was dominated by *Hydroides elegans, Paradialychone ecaudata, Exogone lourei* and *Platynereis bicanaliculata.* Station N at the Port Pilot station in the Main Channel: 76 specimens, 16 species. Three species accounted for 70% of the specimens collected from the

Table 4. The number of species and specimens collected from the longterm test panel exposure period in 2013-2014 by station and date (as months).

	9-12 (2013)	12 (2013) - 4 (2014)	4-8 (2014)	8-10 (2014)
C	*	18-78	13-82	19-63
D	9-140	13-66	20-101	4-13
K	17-90	8-22	6-14	6-10
L	26-132	13-40	10-76	13-46
N	26-264	9-36	11-60	5-11
Totals	33-626	31-252	39-233	26-143

*No data.

short-term test panels: *Hydroides elegans, Neodexiospira pseudocorrugata,* and *Platynereis bicanaliculata.* A total of 30 species and 371 polychaetes was collected from the long-term test panels that were numerically dominated by *Paradialychone ecaudata.* Station Q near the entrance of West Basin: 55 specimens, 12 species. Serpulids and spirorbids accounted for over 50% collected from the test panels.

The water temperature at the nine stations ranged from a low of 11.3°C at Station L in April 2015 to a high of 22.6°C at Station J in September 2014 with a nine stations medium of 17.6°C. The dissolved oxygen levels ranged from a low of 6.0 mg/l at Station D in August 2013 to a high of 10.6 mg/l at Station A in December 2013 with a nine stations medium of 7.6 mg/l (Reish et al. 2015).

Discussion

Comparison of the polychaete populations in 1950-1951 to 2013-2014 indicated a difference in species richness: 22 species compared to 71 species/morphotypes in the later study (Table 2; Fig. 2). *Polydora limicola, Capitella capitata* and *Hydroides pacificus* [= *H. elegans*] were the three most common species in 1950-1951 with peak abundances occurring in the spring months. A suppression in the number of species occurred whenever the dissolved oxygen concentration fell below 4.0 mg/L. Seven common occurring species were present whenever the dissolved oxygen was above this concentration. It is significant that three test blocks were suspended at three different levels at a station in the earlier study compared to only one level in the present study. *Hydroides elegans* was the only common species to both studies. *Neodexiospira pseudocorrugata* and the other small spirorbid species noted in 2013-2014 were not present in the earlier study. Presumably, they were not predent from the test panels or, if present, were smashed in the process of scraping. Only 18 *Capitella capitata* [= *C. capitata* complex], a common pollution indicator species, were present on the test panels exposed in 2013-2014 compared to 141 in the earlier study. Seasonal differences were similar in both studies with peaks in species numbers in the warmer months and lowest during the winter season as indicated in Fig. 2. The seasonal settlement of *Platynereis bicanaliculata* was the same in both studies. Only a few syllids occurred in 1950-1951.

The greater diversity of polychaetes now compared to 1950-1951 reflects the improvement of water and sediment quality that has occurred because of ship channel deepening, the removal of contaminated sediments and sources of pollution, and an improvement of water circulation (Soule and Oguri 1976). A suppression in the number of polychaete species was noted whenever the dissolved oxygen concentration was less than 4.0 mg/L in 1950-1951; it was always above 6.0 mg/L at all stations in 2013-2014 which is above

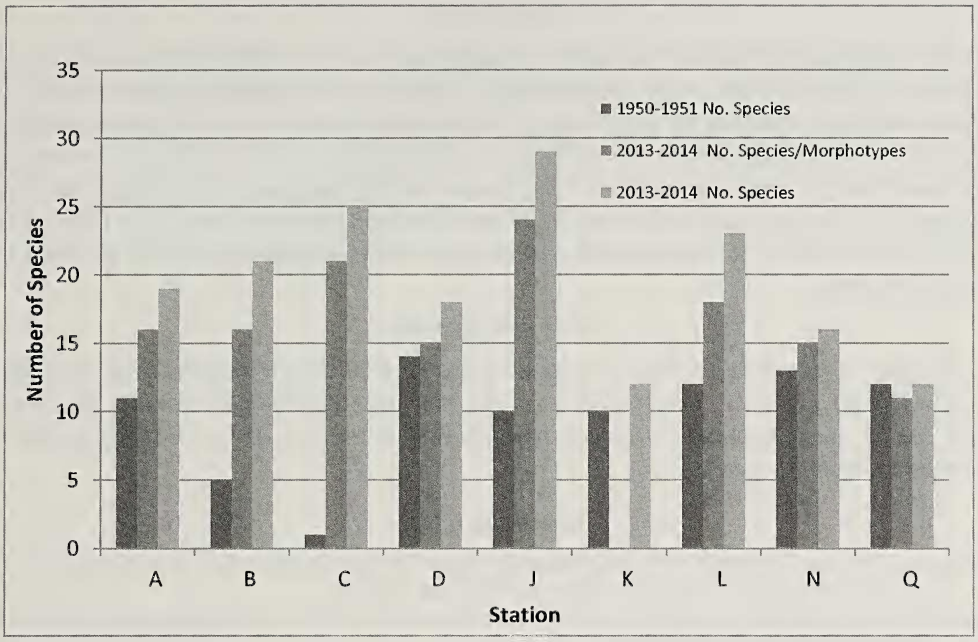

Fig. 2. Comparison of the Number of Species/Morphotypes by Station Collected from Short-Term Exposure Periods on wood blocks in 2013-2014 Compared with 1950-1951.

the level considered necessary for fish life. The polychaete *H. elegans* was the most abundant species in 2013-2014, but it did not compare to 1956 when the pictures were taken of the settlement of this species on a gallon jar after a 28-day exposure period in the harbor (Reish 1961, plate 2, Figs. 2 and 4). These findings agree with the environmental study conducted by MEC Analytical Systems, Inc. (2002) of Los Angeles-Long Beach Harbors. They noted that there has been a steady improvement in the habitat quality as demonstrated by improvement of species diversity and less dominance by pollution tolerant benthic species in the past half century. Rock riprap communities have been relatively stable in the in the past half century. Kelp was restricted primarily to the Outer Harbor breakwater and its coverage has increased since 1986 (MEC 2002). Harbor dredging in the past century has increased the habitat and nursery area for inshore marine fishes (Cross and Allen 1993).

The number of species was greater at all nine stations except Station Q, which remained unchanged but lacked the pollution tolerant species *Capitella capitata.* The largest difference was noted at Stations A, B and C. This was the result of the elimination of waste discharges originating from Dominguez Channel and discharged into Consolidated Slip above Station C. *Capitella capitata* was the only species present in 1950-1951 whereas 25 species were present in the recent study. The number of species increased from 10 to 24 at Station J because of the cessation of cannery waste discharges in Fish Harbor (Reish et al. 1983). An increase in the number of species present in 2013-2014 was expected since environmental improvement in Consolidated Slip was first reported in Reish (1971a) one year after all discharges were eliminated. Thirteen invertebrate species were collected from the floating docks at Station C of which three were polychaetes. *Hydroides* was the dominant species; *Capitella capitata* was not present.

Conclusions

The numerical increase in the number of polychaete species in 2013-2014 compared to 1950-1951 was the result of the improvement in harbor water quality. The elimination of waste discharges entering the Consolidated Slip increased the dissolved oxygen concentration from zero, or near zero in 1951-1952 to over 6.0 mg/l in 2013-1014. The improvement of water quality enabled a diversity of polychaete larvae to migrate into the Inner Harbor and settle on the test panels. The number of species present increased from 22 in 1950-1951 to 71 in 2013-2014. The serpulid *Hydroides elegans* was the dominant species in the Harbor in both studies.

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